Natural Resources
Conservation Service

Montana State Office

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July 16, 2015

SUBJECT: ENG – Exploration Pits for the Big Spring Creek Project

TO: Karen Hoffman
Hydrology and Water Quality Engineer
Natural Resources Conservation Service
Bozeman, Montana

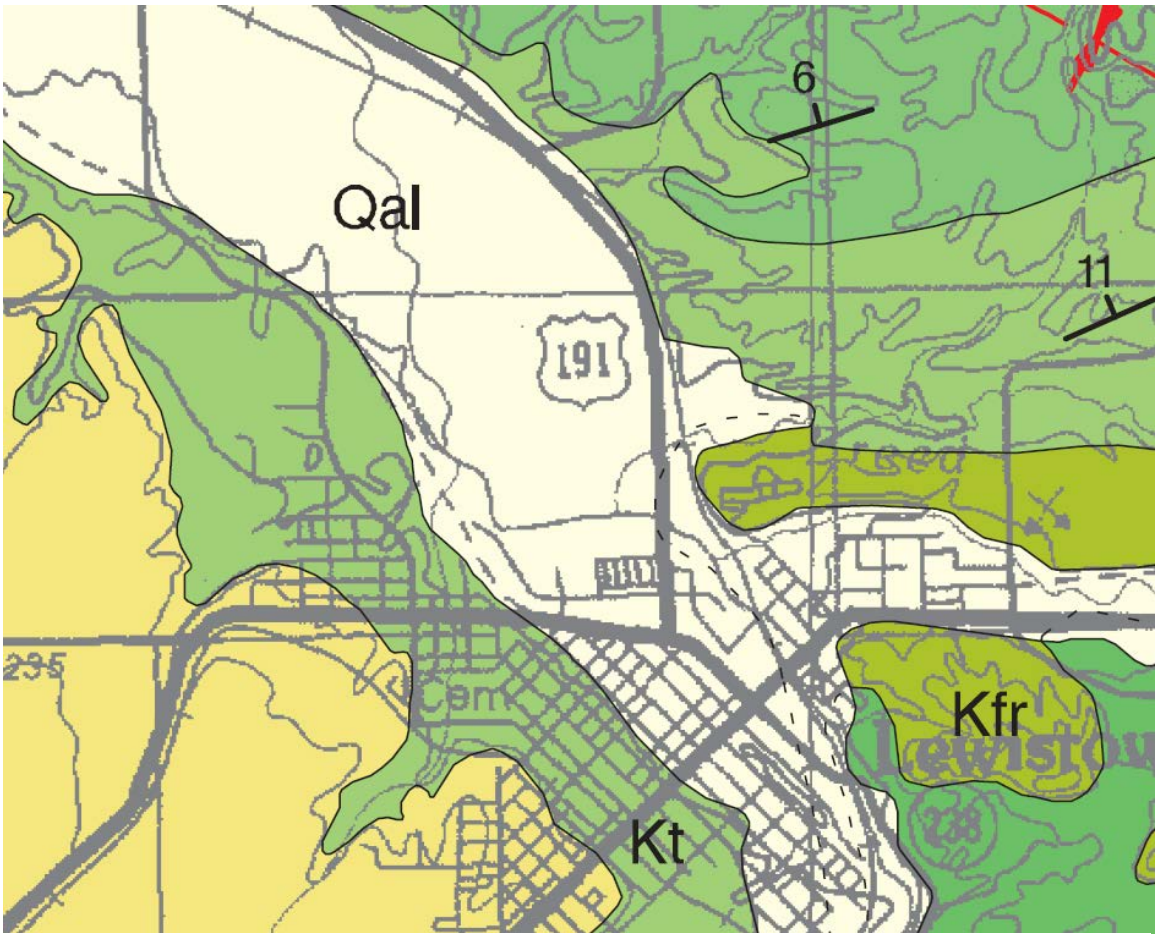
File Code: 210-16-7

On February 25, 2015, I traveled to Lewistown, Fergus County, Montana to observe and log test pits designed to investigate the soil and groundwater conditions for the proposed Big Spring Creek rehabilitation project located just north of Lewistown. The pits were also dewatered in order to estimate the volume of groundwater that will be encountered during construction. Bruce Krueger, Survey and Software Engineer, surveyed the location of the pits, and Karen Hoffman, Hydrology and Water Quality Engineer, assisted with the project. Five pits were excavated with a Cat 315 CL excavator. Pits were dewatered with a 2" portable pump.

The topsoil was generally one to two feet thick and contained very little gravel or larger-sized particles. It is dark-brown to black and is highly productive. Using this soil for reclaiming old channels and other disturbed sites should make re-vegetating disturbed sites relatively easy. Below the topsoil, poorly sorted sandy gravel was encountered. This material contains a few percent of cobbles and boulders. The gravel is very loose and slopes fail back to the angle of repose when wet and disturbed. The vertical walls of the test pits failed when the water table was reached. It will be difficult to excavate below the water table and maintain a design grade and bank slope. If fine sand or silt is encountered, they may liquefy (become quick sand) when disturbed. It may be necessary to over excavate the sand or silt and replace with sandy gravel in order to provide a stable channel. No sand/silt lenses were encountered in this investigation.

The pits produced relatively little water during the dewatering tests. This has been attributed to the little draw down available for the design depths of the excavations. From dewatering observations and consideration of the grain size distribution of the soils involved, it is estimated that channel excavations will initially discharge 3-5 gpm per linear foot of excavated channel with deeper parts of the excavated channel producing up to 15 gpm per linear foot in pool zones. Observation of water entering the pits indicates that local areas may have a greater discharge when first excavated. The water table was about 5 feet above the design depth of the excavations when the pits were dug. If the construction of the project occurs during periods of higher water table, the volume of discharge will be higher, possibly as much 50 to 100% higher.


Project Area



Qal FLOOD PLAIN AND CHANNEL ALLUVIUM (HOLOCENE) — Yellow-tan and gray-tan, poorly to well stratified gravel, sand, silt, and clay deposited in flood plains and channels of modern streams. Locally includes some slightly older Holocene terrace alluvium, where terrace deposits not mapped separately. Thickness not measured.

Qab ALLUVIUM OF DISSECTED BRAID PLAINS AND PEDIMENT SURFACES (QUATERNARY) — Light gray to yellowish-white and gray-brown weathering, moderately stratified deposits of unconsolidated to locally well cemented clay, silt, coarse sand, pebbles, and cobbles. Cemented intervals 1- 5 ft thick have calcareous, commonly iron-stained matrix. Cobbles predominantly rounded, light gray limestone of Madison Group derived from Big Snowy and Little Belt mountain ranges south and southwest of area and more locally from Judith and Moccasin Mountains; cobbles of alkalic igneous rocks, derived from Judith and Moccasin Mountains, common on flanks of these ranges. Deposits appear to be coalesced alluvial braid plain sediments that accumulated down slope by fluvial processes from higher elevations on flanks of adjacent mountain ranges. Unit occurs on flanks of Judith and Moccasin Mountains and forms extensive deposits in western part of map; includes thin gravel veneer on pediment surfaces and several levels of thicker alluvial braid plain deposits now being dissected; may include some terrace deposits.

A similar unit underlies at least five topographic surfaces in west-adjacent Belt quadrangle where unit is considered Quaternary and Tertiary in age Vuke *et al.* (1995). Thickness not measured; less than one to several tens of feet.

Km MOWRY SHALE (UPPER CRETACEOUS) — Contains two distinct lithologies totaling about 165 ft thick; fish scales throughout though not in all intervals. *Sandstones*: light brown-gray weathering, gray, thin- to thick-bedded, fine- to medium-grained, with thin, dark gray, clayey shale interbeds, forming 2 or 3 ledges or low ridges throughout map area; locally cross-stratified, glauconitic, and up to coarse-grained with chert pebbles in coarse fraction; thin (1/2 to 2 in.) white to orange-stained bentonite beds common throughout. *Siltstones*: light silvery-blue to white weathering, blue-gray, brittle, thin-bedded siltstone and blue-gray shale with common powdery yellow mineral (jarosite) on bedding planes; predominantly thin-bedded to laminated, commonly exposed in light-colored barren patches across slopes or ridge tops; generally developed above sandstone interval, but where sandstones poorly developed, may comprise most of formation. Lowermost part of formation, generally not exposed, brown-gray or blue-gray, fissile, laminated and bentonitic shale. Persistent 2- to 3-ft bentonite bed at base probably is Arrow Creek bed of Reeside and Cobban (1960). Approximate thickness 198 ft (60 m; Lindsey, 1982) .

Kt THERMOPOLIS SHALE (LOWER CRETACEOUS) — Composed of dark gray to black weathering shale, tan-gray weathering sandy shale, olive-tan weathering laminated very fine-grained sandstone, and dark gray-brown weathering, quartzose, medium-grained sandstone; numerous thin bentonite beds throughout. Three members recognized but not mapped separately. Generally valley-forming and poorly exposed throughout map area. *Lower part (Skull Creek Member)*: underlying Warm Spring Creek in Lewistown area and MacDonald Creek, east of Judith Mountains; composed of very black, fissile, unresistant shale with numerous thin, iron-stained sandstone laminae in lower part ("Dakota silt" of subsurface); approx. 228 ft (Lindsey, 1982), 25l ft (Porter *et al.*, 1997, Pl. 4). *Middle part (unnamed sandy member)*: generally sandy with dark reddish-purple to purple-black ironstone concretions common; 3 ledges of fine- to coarse-grained sandstone 4 to 5 ft thick separated by 40 to 60 ft of bioturbated, blocky weathering, sandy shale; sandstones contain black chert, glauconite, and locally abundant fish debris in cross-stratified and ripple-laminated beds with animal traces on bedding plane surfaces; a chert-pebble bed lies just below or at base of lowest sandstone; sandstones may be stratigraphically equivalent to Vaughn Member of Blackleaf Formation (Cobban *et al.*, 1976) as mapped farther west in parts of Belt quadrangle (Vuke *et al.*, 1995); approx. 470 ft (Lindsey, 1982), 313 ft (Porter *et al.*, 1997, Pl. 4). *Upper part (Shell Creek Shale):* dark blue-gray weathering, soft, fissile, dark black, clayey shale; generally unexposed; unit included in informal sandy member by Johnson and Smith (1964); approx.107 ft (Porter *et al.*, 1997; Pl. 4). Total formation thickness in

Moccasin Mountains 770 ft (234 m; Lindsey, 1982), 671 ft on small dome on east flank Judith Mountains, north of Maiden Creek Canyon (Porter *et al.*, 1997, pl. 5).

Kfr FALL RIVER SANDSTONE (LOWER CRETACEOUS) — Tan-brown-weathering, light gray-tan or buff-tan, predominantly fine-grained quartzose sandstone, commonly brown-speckled on fresh surfaces. Cross-stratified and ripple-laminated in thin to thick beds with numerous very thin dark shale partings. Interbedded dark, clayey to sandy shale. Invertebrate tracks and trails on bedding plane surfaces. Base of unit sandstone or a medium gray sandy shale interval resting on Kootenai Formation red beds. Caps benches south and east of Lewistown. West of Judith Mountains, formation combined with Thermopolis Formation because of poor exposures, though occasionally seen in float. Thickness approximately 53 ft (16 m; Lindsey, 1982).

Kk KOOTENAI FORMATION (LOWER CRETACEOUS) — Dark to medium red, gray-green and minor buff-colored silty, blocky weathering shale, and fine- to coarse-grained, chert-bearing, feldspathic, commonly cross-stratified sandstone. Thick basal sandstone (up to 100 ft, Vine, 1956; Third Cat Creek sandstone of subsurface) is gray, medium- and coarse-grained, conglomeratic, chert-bearing, cross-stratified. Middle part of formation dominated by varicolored mudstones, predominantly red and yellow-tan; thin, gray-white nodular limestone beds occur locally in section above basal sandstone. Upper part of formation interbedded red mudstones and yellow and brown, thin-bedded, fine-grained, quartzose sandstones with minor chert and feldspar (Second Cat Creek sandstone of subsurface). Approximate formation thickness in Moccasin Mountains 545 ft (165 m; Lindsey, 1982); in Judith Mountains, 330 to 495 ft (100-150 m; Goddard, 1988).

Geology

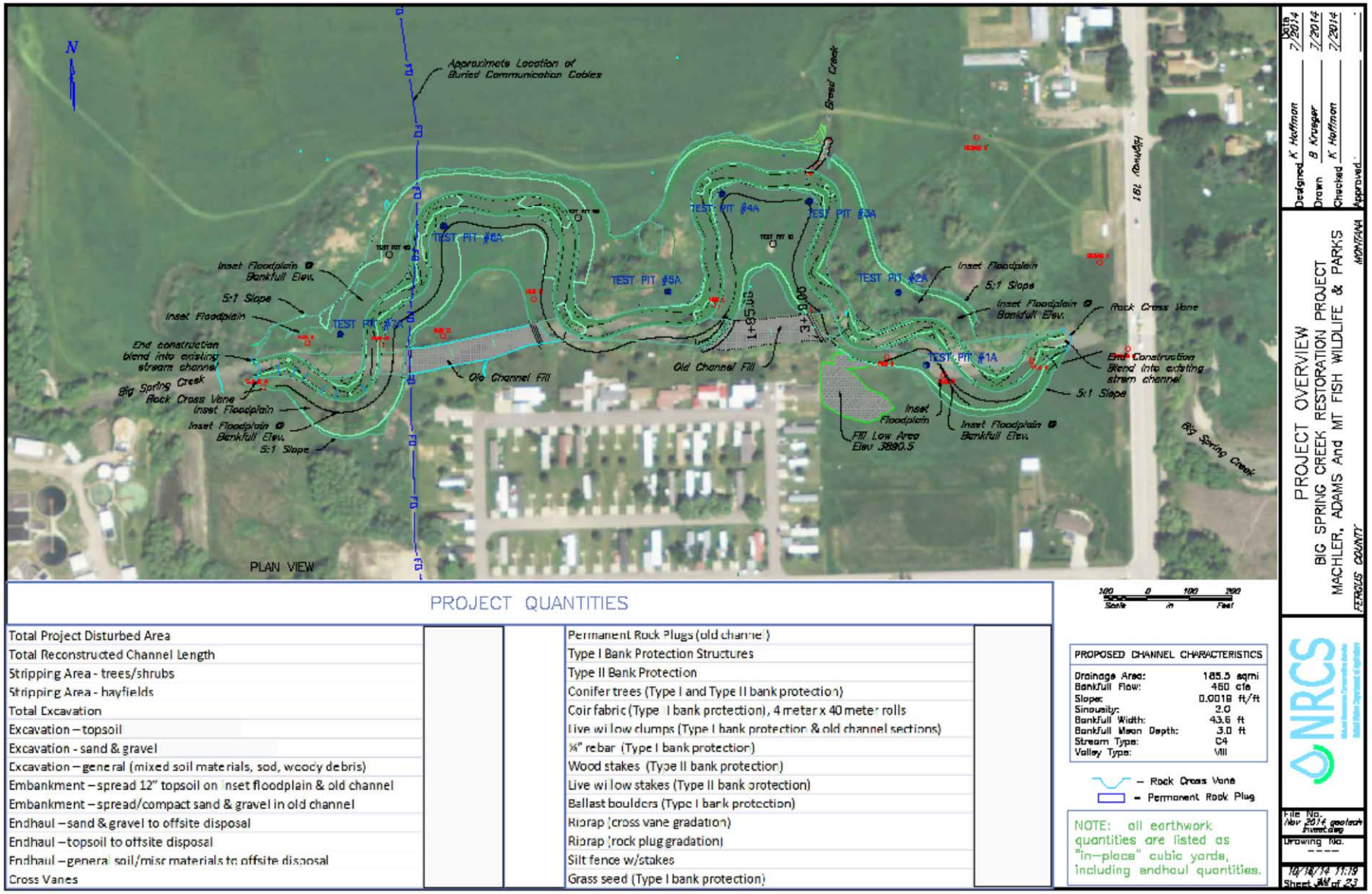
The site of the proposed rehabilitation project is underlain by top soil over poorly sorted sandy gravel with cobbles and boulders, over Cretaceous Fall River Sandstone. The Fall River Sandstone is not likely to be cavernous or have other characteristics that would adversely affect the project. Bedrock is not likely to be encountered in the excavations so no special excavation requirements are anticipated for the project other than dewatering and potential liquefaction of fine sand and silts if they are encountered at or below the water table.

Please call me at (406) 587-6830 if you have any questions or concerns.

Michael R. Garverich, P.E.
State Geologist

Appendix A, Map of Test Pit Locations
Appendix B, Test Pit Images
Appendix C, Test Pit Logs
Appendix D, Soil Classification Results

Appendix A, Map of Test Pit Locations



PROJECT QUANTITIES

Total Project Disturbed Area			Permanent Rock Plugs (old channel)		
Total Reconstructed Channel Length			Type I Bank Protection Structures		
Stripping Area - trees/shrubs			Type II Bank Protection		
Stripping Area - hayfields			Conifer trees (Type I and Type II bank protection)		
Total Excavation			Coir fabric (Type I bank protection), 4 meter x 40 meter rolls		
Excavation – topsoil			Live willow clumps (Type I bank protection & old channel sections)		
Excavation - sand & gravel			⅝" rebar (Type I bank protection)		
Excavation – general (mixed soil materials, sod, woody debris)			Wood stakes (Type II bank protection)		
Embankment – spread 12" topsoil on inset floodplain & old channel			Live willow stakes (Type II bank protection)		
Embankment – spread/compact sand & gravel in old channel			Ballast boulders (Type I bank protection)		
Endhaul – sand & gravel to offsite disposal			Riprap (cross vane gradation)		
Endhaul – topsoil to offsite disposal			Riprap (rock plug gradation)		
Endhaul – general soil/misc materials to offsite disposal			Silt fence w/stakes		
Cross Vanes			Grass seed (Type I bank protection)		

100 0 100 200 Feet

PROPOSED CHANNEL CHARACTERISTICS	
Drainage Area:	185.5 sqmi
Bankfull Flow:	460 cfs
Slope:	0.0018 ft/ft
Sinuosity:	2.0
Bankfull Width:	43.6 ft
Bankfull Mean Depth:	3.0 ft
Stream Type:	C4
Valley Type:	VIII

– Rock Cross Vane
– Permanent Rock Plug

NOTE: all earthwork quantities are listed as "in-place" cubic yards, including endhaul quantities.

File No. Nov 2014 geotech investigation
Drawing No. ----
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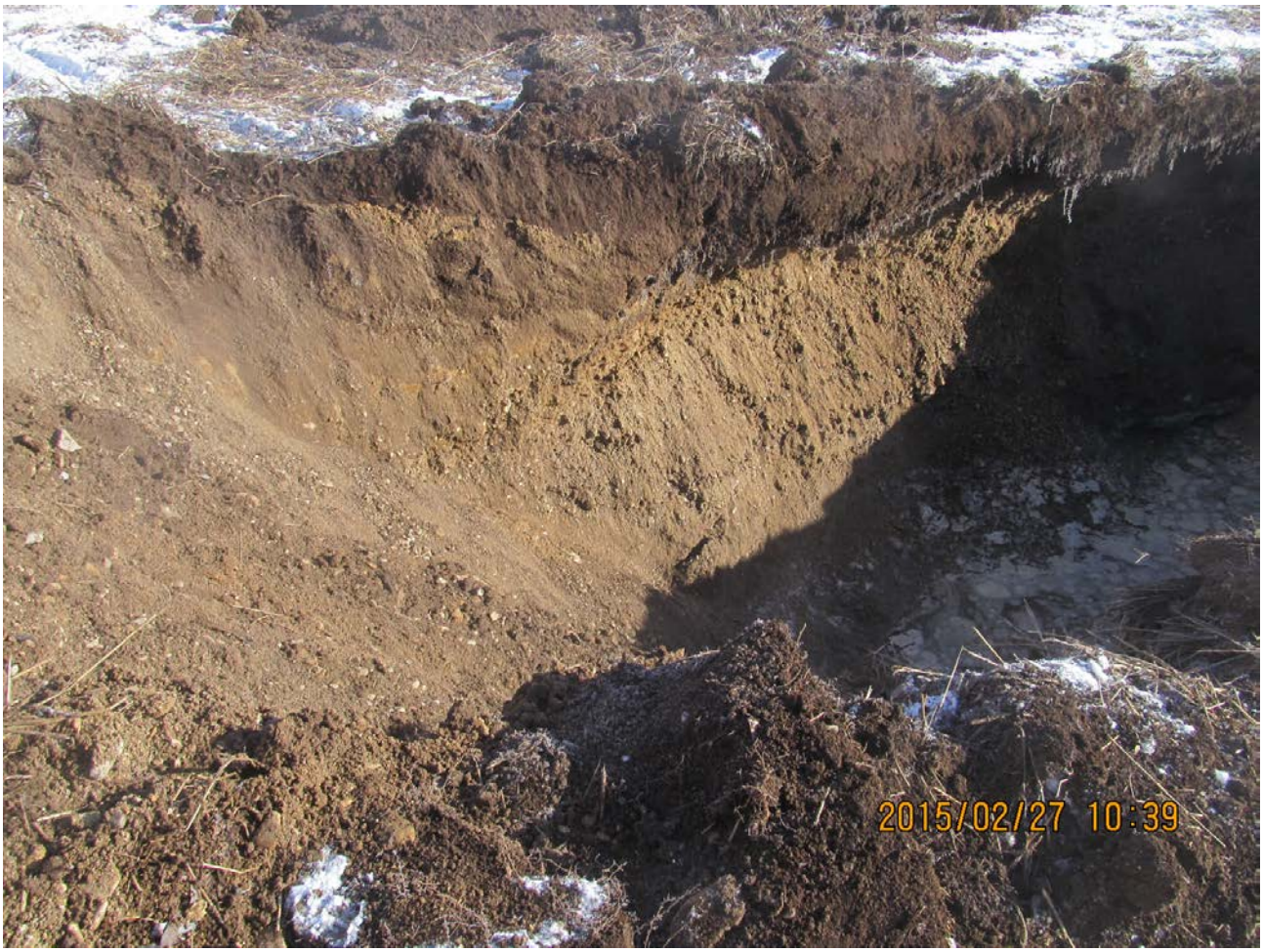
Sheet 24 of 23

Appendix B, Test Pit Images

Test Pit 3a

Test Pit 4a



Test Pit 5a

Test Pit 5a Excavated Soil

Test Pit 6a

Test Pit 7a

View of Typical Soil Profile

Appendix C – Test Pit Logs

BORING NUMBER SPTP-03A

CLIENT Karen Hoffman
PROJECT NAME Big Spring Creek Test Pits
PROJECT NUMBER
PROJECT LOCATION N 1/2, SW 1/4, Sec 19, T 15 N, R 18 E, Fergus County, Mor
DATE STARTED 2/26/15 **COMPLETED** 2/26/15
GROUND ELEVATION 3891.48 ft **HOLE SIZE** inches
DRILLING CONTRACTOR DeBuff
GROUND WATER LEVELS:
DRILLING METHOD CAT 315CL
AT TIME OF DRILLING ---
LOGGED BY MR Garverich **CHECKED BY**
AT END OF DRILLING ---
NOTES
0.1hrs AFTER DRILLING 9.50 ft / Elev 3881.98 ft

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0		SC-SM		(SC-SM) Top Soil	
				1.0	3890.5
		SC-SM		(SC-SM) Silty clayey sand, light brown, moist, loose, contact with underlying gravel is uneven	
2.5					
5.0				5.0	3886.5
		GP		(GP) poorly graded sandy gravel with thin clay beds, brown, moist to wet near top of gravel, loose, very low angle of repose after disturbance, swl 9.5'	
7.5					
10.0					
12.5					
				14.4	3877.1
				Bottom of borehole at 14.4 feet.	

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BORING NUMBER SPTP-04A

CLIENT Karen Hoffman
PROJECT NAME Big Spring Creek Test Pits
PROJECT NUMBER
PROJECT LOCATION N 1/2, SW 1/4, Sec 19, T 15 N, R 18 E, Fergus County, Mor
DATE STARTED 2/26/15 **COMPLETED** 2/26/15
GROUND ELEVATION 3891.43 ft **HOLE SIZE** inches
DRILLING CONTRACTOR DeBuff
GROUND WATER LEVELS:
DRILLING METHOD CAT 315CL
AT TIME OF DRILLING ---
LOGGED BY MR Garverich **CHECKED BY**
AT END OF DRILLING ---
NOTES
AFTER DRILLING 10.00 ft / Elev 3881.43 ft

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0		SC-SM		(SC-SM) topsoil	
				1.0	3890.4
				(SC-SM) Silty clayey sand, light brown, moist, loose, contact with underlying gravel is uneven	
2.5					
5.0		SC-SM			
7.5					
				8.5	3882.9
				(GP) poorly graded sandy gravel with thin clay beds, 8-10 inch, subangular fragments near base, Excavator bucket bumping on covered substrate at bottom of hole, likely near bedrock, brown, moist to wet near top of gravel, loose, very low angle of repose after disturbance, swl 10'	
10.0		GP			
12.5					
				13.9	3877.5
				Bottom of borehole at 13.9 feet.	

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BORING NUMBER SPTP-05A

CLIENT Karen Hoffman
PROJECT NAME Big Spring Creek Test Pits
PROJECT NUMBER
PROJECT LOCATION N 1/2, SW 1/4, Sec 19, T 15 N, R 18 E, Fergus County, Mor
DATE STARTED 2/27/15 **COMPLETED** 2/27/15
GROUND ELEVATION 3889.47 ft **HOLE SIZE** inches
DRILLING CONTRACTOR DeBuff
GROUND WATER LEVELS:
DRILLING METHOD CAT 315CL
AT TIME OF DRILLING ---
LOGGED BY MR Garverich **CHECKED BY**
AT END OF DRILLING ---
NOTES
AFTER DRILLING 7.50 ft / Elev 3881.97 ft

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0		SC-SM		(SC-SM) topsoil	
				1.0	3888.5
		SC-SM		(SC-SM) Silty clayey sand, light brown, moist, loose, contact with underlying gravel is uneven	
2.5				3.0	3886.5
		GP		(GP) poorly graded sandy gravel with thin clay beds, brown, moist to wet near top of gravel, loose, very low angle of repose after disturbance, swl 5.5'	
5.0					
7.5					
10.0					
				11.7	3877.8
				Bottom of borehole at 11.7 feet.	

BORING NUMBER SPTP-06A

CLIENT Karen Hoffman
PROJECT NAME Big Spring Creek Test Pits
PROJECT NUMBER
PROJECT LOCATION N 1/2, SW 1/4, Sec 19, T 15 N, R 18 E, Fergus County, Mor
DATE STARTED 2/26/15 **COMPLETED** 2/26/15
GROUND ELEVATION 3886.76 ft **HOLE SIZE** inches
DRILLING CONTRACTOR DeBuff
GROUND WATER LEVELS:
DRILLING METHOD CAT 315CL
AT TIME OF DRILLING ---
LOGGED BY MR Garverich **CHECKED BY**
AT END OF DRILLING ---
NOTES
AFTER DRILLING 5.50 ft / Elev 3881.26 ft

DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0		SC-SM		(SC-SM) topsoil	
				1.0	3885.8
2.5		SC-SM		(SC-SM) Silty clayey sand, light brown, moist, loose, contact with underlying gravel is uneven	
				4.0	3882.8
5.0		GP		(GP) poorly graded sandy gravel with thin clay beds, brown, moist to wet near top of gravel, loose, very low angle of repose after disturbance, swl 5.5'	
7.5					
10.0					
12.5				12.6	3874.2

Bottom of borehole at 12.6 feet.

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BORING NUMBER SPTP-07A

CLIENT Karen Hoffman
PROJECT NAME Big Spring Creek Test Pits
PROJECT NUMBER
PROJECT LOCATION N 1/2, SW 1/4, Sec 19, T 15 N, R 18 E, Fergus County, Mor
DATE STARTED 2/27/15 **COMPLETED** 2/27/15
GROUND ELEVATION 3886.32 ft **HOLE SIZE** inches
DRILLING CONTRACTOR DeBuff
GROUND WATER LEVELS:
DRILLING METHOD CAT 315CL
AT TIME OF DRILLING ---
LOGGED BY MR Garverich **CHECKED BY**
AT END OF DRILLING ---
NOTES
AFTER DRILLING 5.50 ft / Elev 3880.82 ft

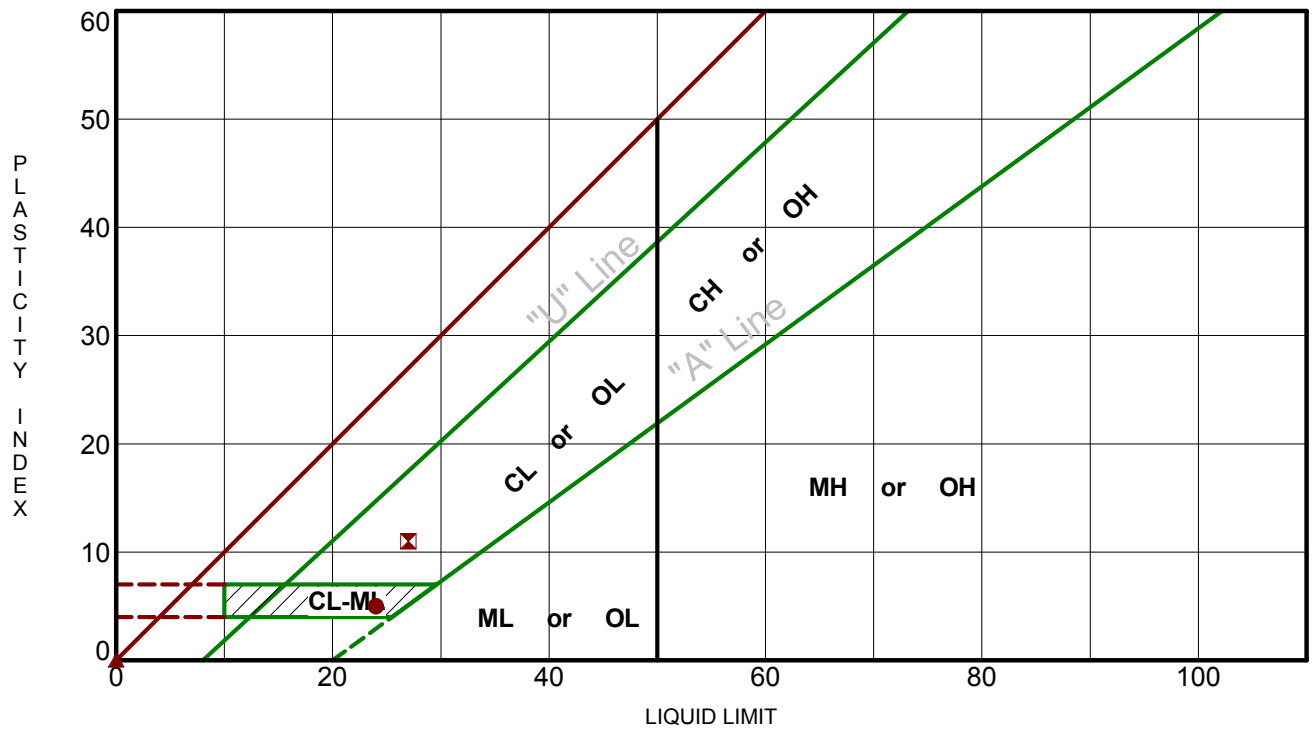
DEPTH (ft)	SAMPLE TYPE NUMBER	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	
0.0		SC-SM		(SC-SM) topsoil	
2.0					3884.3
2.5		GP		(GP) poorly graded sandy gravel with thin clay beds, brown, moist to wet near top of gravel, loose, very low angle of repose after disturbance, swl 5.5' same as creek	
5.0					
6.0					3880.3

Bottom of borehole at 6.0 feet.

Appendix D - Soil Classification Results

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID		Depth	LL	PL	PI	Fines	USCS	Description
●	3	1 - 6	24	19	5		SC-SM	SILTY, CLAYEY SAND
⊠	4	2 - 3	27	16	11		SC	CLAYEY SAND
▲	6	3	NP	NP	NP		GP	POORLY GRADED GRAVEL with SAND

PROJECT: Big Spring Creek

SITE: 12 3rd Street NW
Great Falls, Montana

Terracon
1392 13th Ave. SW
Great Falls, Montana

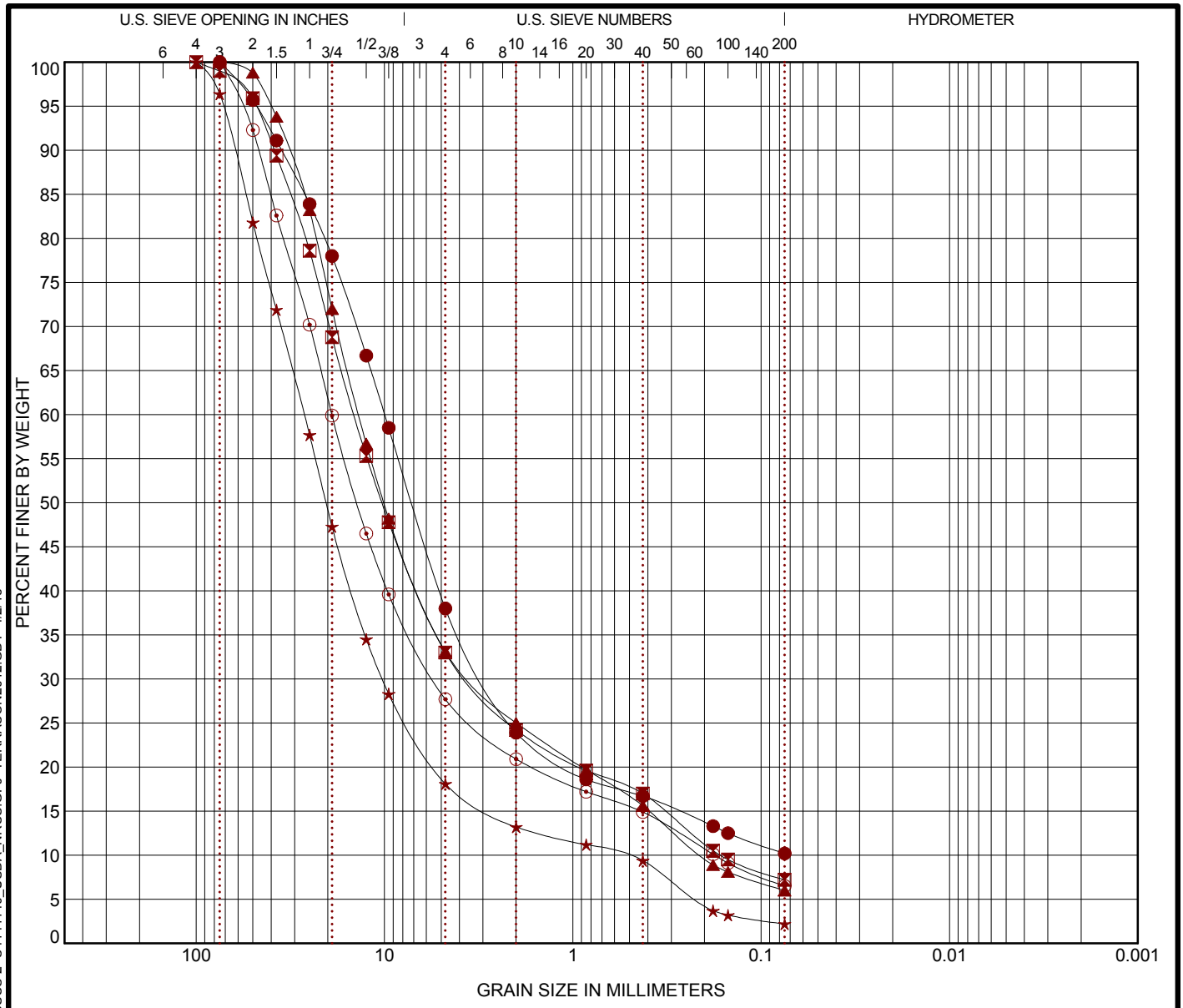
PROJECT NUMBER: C4141140

CLIENT: USDA-NRCS
Great Falls, MT

EXHIBIT: B-1

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID		Depth	USCS Classification	LL	PL	PI	Cc	Cu
●	3	6 - 11	POORLY GRADED GRAVEL with CLAY and SAND				11.99	141.46
⊠	4	10	POORLY GRADED GRAVEL with CLAY and SAND				5.26	88.01
▲	5	10	POORLY GRADED GRAVEL with CLAY and SAND				4.10	66.01
★	6	4	POORLY GRADED GRAVEL with SAND				7.34	49.86
⊙	7	2	POORLY GRADED GRAVEL with CLAY and SAND				8.76	107.78

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	3	6 - 11	75	9.989	2.908		62.0	27.8	10.2	
⊠	4	10	100	14.462	3.537	0.164	66.0	25.8	7.2	
▲	5	10	75	13.681	3.411	0.207	66.9	27.1	6.0	
★	6	4	100	26.697	10.242	0.535	78.3	15.9	2.2	
⊙	7	2	75	19.051	5.431	0.177	72.3	21.2	6.5	

PROJECT: Big Spring Creek

SITE: 12 3rd Street NW
Great Falls, Montana

Terracon
1392 13th Ave. SW
Great Falls, Montana

PROJECT NUMBER: C4141140

CLIENT: USDA-NRCS
Great Falls, MT

EXHIBIT: B-2